Radiology Review

Joseph J. Pizzimenti, OD, FAAO
Ft. Lauderdale, FL

USA PONDERED RADIOLOGICAL WEAPONS IN COLD WAR

- Newly declassified documents
- U.S. Army explored potential for using radioactive poisons to assassinate "important individuals" in 1948

Radiation In the World News

- In 2006, an unknown assailant used polonium-210 to kill Kremlin critic and former Russian spy Alexander Litvinenko
- Positive uses of radiation in health care.

Radiology Review: Why??

- Today’s optometrists routinely care for patients that require neuroimaging studies.
- As primary healthcare providers, we may be in a position where we must order and even interpret imaging studies of intraocular structures, orbits and brain.
- We should be familiar with the various types of radiologic tests in order to work with other providers on behalf of our patients.
About Radiology: Course Goals

- A brief history of radiology
- Types of radiologic examinations
- Glossary of terms; radiology vocabulary
- What to expect from an imaging exam
  - Instrumentation
  - How it works
  - Ordering protocols
  - Safety issues, contraindications, pediatric considerations
- A clinical approach to image interpretation
  - Application to patient cases

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Types of Radiologic Examinations

- Procedures may be grouped by the means in which images are produced:
  - Transmission imaging: radiation sent through body and detected on other side.
    - Plain films, fluoroscopy, mammography, CT
  - Reflection imaging: radiation passes partially into body and is reflected back.
    - Ultrasound, Optical Coherence Tomography
  - Emission imaging: generate radiation source inside body and detect radiation as it leaves body.
    - MRI, Nuclear medicine

Some Milestones in Radiology

1895 X-rays discovered by Wilhelm Conrad Roentgen; the first x-ray picture taken.
1897 First single-film full body skeletal radiograph (William Morton).
1898 First deliberate therapeutic application of x-rays; Marie and Pierre Curie announce the discovery of radium.
1899 X-ray used to localize brain tumor in a patient.
1900 Nobel Prize awarded to Roentgen; American Roentgen Ray Society founded.
History

- A 34 year-old black female presents symptoms of bilateral redness x 7 days
- Gradual onset, gradual worsening
- Mild pain, mild photophobia OU
- Ocular history positive for previous episodes OU

Clinical Findings

- Biomicroscopy
  - 2+ cells in AC OU
  - “Mutton fat” deposits on endothelium OU
  - Iris nodules OU
  - Areas of posterior synechia OU
- TAP: 9 mmHg OD/11 mmHg OS
- DFE
  - “Snowbanking” inferior PP OU

Anterior Seg Findings
Posterior Seg “Puff-balls” and “Snowbanking”

What is your ocular diagnosis?

Assessment

- Bilateral anterior uveitis
  - Probably recurrent/chronic
- Granulomatous
  - Mutton-fat KPs
  - Iris nodules
- Prior posterior seg inflammation

What is your plan?

Ocular management
Systemic testing?
Consultation?
A granulomatous uveitis has an increased likelihood of being part of a s_________ disease process.

**Actual Management**
- Treated anterior uveitis using conventional topical meds.
- Ordered systemic “uveitis” work-up
  - ACE will be elevated in 50% to 80% of patients with active S________
- Chest imaging

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**Bilateral Hilar Lymphadenopathy on Chest X-Ray**

“Potato” nodes

**Bilateral Hilar Lymphadenopathy on CT Scan of Chest**
Outcome/Summary

- Sarcoidosis
  - Patient was also placed on po Prednisone (short-term)
  - Good ocular response to medical therapy
- What to order:
  - Chest X-ray
  - CT of chest and abdomen

Types of Radiologic Examinations

- X-ray (Plain film)/Conventional Radiography
- Digital Radiography
- Fluoroscopy
- Mammography
- Computed Tomography (CT)
- Magnetic Resonance Imaging (MRI)
- Nuclear Medicine
- Ultrasonography/Echography
Glossary of Terms

- **Radiology**
  - The scientific discipline of medical imaging using ionizing radiation, radionuclides, nuclear magnetic resonance, and ultrasound.
- **Radiopaque/Radiolucent**
  - Impenetrable by x-rays or any other form of radiation/penetrable.
- **Contrast dye or media**
  - A substance that has a different opacity from soft tissue on imaging studies.

**CONVENTIONAL RADIOGRAPHY**

- X-rays are part of the electromagnetic spectrum
  - Emitted as a result of bombardment of a t_______ anode by free electrons.
  - Plain films are produced by their passage through the patient and exposing a radiographic film.
- Plain films are particularly useful for imaging:
  - ➔ bone and sinuses (bony orbit)
  - ➔ abdomen and chest
  - ➔ skeletal system: spine, joints, degenerative, metabolic and metastatic disease
Fluoroscopy

- Examination of tissues and deep structures using a device that projects radiographic (X-ray) images in a movie-like sequence onto a screen or monitor.
- Fluoroscopy is often used to observe the digestive tract (Upper GI series - Barium Swallow, Lower GI series - Barium Enema)
**Mammography**

Imaging examination of the breast by means of X-rays.

**Mammogram**

**MILESTONES IN RADIOLOGY**

1898

First Deliberate Therapeutic Application Of X-rays

Pierre And Marie Curie Announce The Discovery Of Radium
MILESTONES IN RADIOLOGY

1972
Computer Assisted Tomography
Is Developed By Hounsfield And Cormack

1975
Patent Issued To R.S. Ledley For His Whole-body Ct Diagnostic X-ray System (Cat Scan)

Computed Tomography

- A computed tomography (CT) scan uses X-rays to create detailed pictures of structures inside of the body.
- Images bone, muscle, blood, soft tissue (MRI superior)
  - Contrast dye
  - Can vary cuts from 1mm to 10mm thick

Computed Tomography (CT) or CAT Scan (computerized axial tomography)

- Images anatomical information from a cross-sectional plane of the body.
- Each image generated by computer synthesis of x-ray transmission data obtained in many different directions within a given plane.
**CT Scan**

- Above, modern CT equipment.
- Below, normal CT of brain w/contrast.

**COMPUTED TOMOGRAPHY**

**USES**
- Any region of the body can be scanned.
- Staging tumors for secondary spread and effects on bone.
- Radiotherapy planning

**ADVANTAGES**
- Good contrast resolution.
- Precise anatomical detail.
- Rapid examination technique.
- In contrast to ultrasound, diagnostic images are obtained in obese patients as fat separates the abdominal organs.

**CT Scan**

- Data from multiple cross-sections can be assembled into 3-D images.

**CTA**

- Angiography (CTA)
  - Imaging of vessels using X-rays after injection of iodine-containing contrast medium
  - Example: abdominal aorta, carotids
  - Detect aneurysms, AVMs
COMPUTED TOMOGRAPHY

OPHTHALMIC USE OF CT
• Intraocular/orbital foreign body
• Head and face trauma; fractures, blood detection
• CVA, amaurosis fugax
• Orbital disease (esp. Graves’), EOM enlargement.

**We use CT mainly to r/o orbital cellulitis, orbital trauma.

ORBITAL CELLULITIS

CT Scan-Orbital Cellulitis

CT Scan- Disadvantages
- High cost of equipment and scan (compared to plain films).
- Scanning mostly restricted to the transverse (axial) and coronal planes (no sagittal).
- High dose of ionizing radiation for each examination.
- Contraindicated in pregnancy, child
- Iodine-based contrast is contraindicated in kidney Dx, allergy
Glossary

- Ultrasound
  - Method of obtaining images from inside the body through the use of high frequency sound waves.
  - Doppler
    - Ultrasound technique used to detect moving blood cells or other structures.

Carotid Doppler

Carotid Bruit

Ophthalmic Ultrasound: RD

Retinal Detachment
MILESTONES IN RADIOLOGY

1960
Ultrasound Imaging Becomes A Recognized Medical Tool

Uses of Ultrasound in Medicine

Brain: Imaging the neonatal brain.
Ocular: A-scan (biometry), B-scan (tumors, Optic Nerve disease)
Thorax: Confirms pleural effusions and pleural masses
Abdomen: Visualizes liver, gallbladder, pancreas, kidney.
Pelvis: Useful for monitoring pregnancy; uterus and ovaries.
Peripheral: Assesses thyroid, testes and soft-tissue lesions.
Doppler Ultrasound

Used for:
- assessment of cardiac chambers and heart valves
- arterial flow studies, especially carotids and peripheral vascular disease
- venous flow studies for detection of deep-vein thrombosis

DOPPLER ULTRASOUND

ADVANTAGES
- Relatively low cost of equipment.
- Non-ionizing and safe.
- Scanning in any plane.
- Can be repeated frequently, for example pregnancy follow up.
- Detection of blood flow, cardiac and fetal movement.
- Portable equipment can be taken to the bedside for ill patients.
- Aids biopsy and drainage procedures.

DISADVANTAGES
- Operator dependent.
- Inability of sound to cross an interface with either gas or bone.
  causes unsatisfactory visualization of underlying structures.
- Scattering of sound through fat produces poor images in obesity.
Case History
- 63-year-old white female presented with recent onset of diplopia and an irritated, proptotic OS.
- PMHx: L Facial N. palsy X 30 years
- FMHx: (+)Breast Cancer (aunt), (+)Ovarian Cancer (sister)

Primary gaze
- High mag

Right gaze
- Note underaction of OS
- No abduction nystagmus OD (no INO)
**Ancillary Testing**
- EOM: UA of OS in most POG
- Modified Forced Ductions
  - OS: (+) resistance in all fields of gaze, retropulsion
- CN VII
  - Orbicularis weakness OS
- Ice-pack Test (r/o MG)
  - no change in ptosis, EOMs, diplopia

**What is your diagnosis?**
Etiology of diplopia?
Etiology of proptosis?

**Differential Diagnosis**
- Restrictive disease OS, ukn. etiology
  - Thyroid work-up
  - Orbital process
    - Orbital Inflammatory Pseudotumor
    - Mass
- C________ s______ syndrome

**What is your plan?**
Systemic testing?
Consultation?
Neuroimaging?
**Neuroimaging**

- Contrast enhanced MRI of the orbit, brain, chiasm, and cavernous sinus

**Results:**
- Enhancing mass involving lacrimal region of the left orbit with enlargement of lateral rectus.
- Possible involvement of the superior rectus and levator palpebrae superioris.
  - No evidence of cavernous sinus mass.
  - No optic nerve or chiasmal involvement.

**MRI axial section through orbits--T1**
- Note thickening in region of Left LR and lacrimal gland

**Axial section through orbits (low mag)**
- Note same area of thickened LLR/lacrimal gland

**Para-saggital view through Left orbit--T1**
- Shows soft tissue mass superior/anterior to globe
Contrast-enhanced axial view through orbits
- Shows enhancement of soft tissue mass in region of Left lacrimal gland

Coronal view through orbits
- Shows thickening of Left lacrimal gland region

Orbital Biopsy Results
- Malignant neoplasm c/w metastatic carcinoma from the breast with strong staining for the estrogen receptor.
- Diagnostic Mammogram
  - 1 cm spiculated lesion in the upper aspect right breast with associated pleomorphic calcifications
  - 1 cm lesion of upper aspect of the left breast, also suspicious for neoplasm
**Treatment**

- **Systemic**
  - Hormone therapy: Tamoxifen 10 mg BID
  - Goal is to shrink breast mass b/f surgery
  - After response to hormone therapy, bilateral mastectomy indicated
- **Ocular**
  - Partial tarsorraphy OS for exposure
  - Consider radiation therapy OS to improve symptoms

**Case Summary**

- **Metastatic Disease**
- What to order:
  - MRI/CT scan
  - Mammography
  - Ultrasound

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**MILESTONES IN RADIOLOGY**

- **1973**
  - Magnetic Resonance Imaging is pioneered by P.L. Lauterbur

- **1980**
  - MRI of brain done on first patient

**Magnetic Resonance Imaging**

- Emission imaging
- Utilizes signal from change of quantum states of (Hydrogen) proton spin.
- Body placed in a strong magnetic field
  - 10,000 stronger than the earth’s magnetic field strength.
- MRI applies an RF (radio frequency) pulse that is specific to hydrogen.
- The system directs the pulse toward the area of the body we want to examine.
MRI

- Protons excited by RF pulse
  - Protons in higher energy state — NMR
- RF field switched off
- Hydrogen protons return to their natural alignment within the magnetic field and release their excess stored energy.
- When they do this, they give off a signal that the MRI coil now picks up and sends to the computer system.
- What the system receives is mathematical data that is converted, through the use of a Fourier transform, into a picture that we can put on film.

MILESTONES IN MRI

1989
- MRI Angiography (MRA) Allows Non-invasive Imaging Of Blood Vessels Without Radiation Or Contrast Injection

1993
- Open MRI For Claustrophobic Or Obese Patients
Magnetic Resonance Imaging

- MR scanning produces images by utilizing the magnetic properties of certain nuclei, principally those of hydrogen in water molecules.
- Basic principle:
  - MRI is a study of the response of magnetized tissue to a pulse of radio-frequency.
  - Pathological (diseased) tissue returns different signals compared to normal tissue.
- Computer processes this energy into a digital signal, with conversion to a grey scale image.

MRI--Then and Now

Uses
- CNS: technique of choice for brain and spinal imaging (soft tissue).
- Musculoskeletal: imaging joints and muscular abnormalities.
- Cardiac: enables the diagnosis of many conditions.
- Thorax: assessment of vascular structures in the mediastinum.
- Abdomen: structures are well visualized, surrounded by high signal from surrounding fat.
- Pelvis: staging of prostate, bladder and pelvic neoplasms.

Advantages
- Can image in any plane.
- Non-ionizing and hence believed to be safe to use.
- Excellent anatomical detail, especially of soft tissues.
- Visualizes blood vessels without contrast: magnetic resonance angiography/venography (MRA/V).
- No bony artifacts due to lack of signal from bone.
- Intravenous contrast utilized much less frequently than CT.
**MAGNETIC RESONANCE IMAGING**

**Disadvantages**
- High operating costs
- Poor images of lung fields
- Inability to show calcification
- Fresh blood in recent hemorrhage not as well visualized (as by CT)
- MRI can be difficult to tolerate/exam times > CT.

**MRI - Contraindications**
- Patients with pacemakers
- Cochlear implants
- Metallic foreign bodies
- Arterial aneurysmal clips
- Stents (may be forced out of position)

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**MRI: Characteristics**
- Signal intensity determined by:
  - Proton density
  - T1 relaxation time
  - T2 relaxation time
- Proton density is the concentration of protons in the tissue (water, proteins, fat)

**MRI**
- T1 and T2 define the way protons revert back to resting states after initial RF pulse.
- To determine which pulse sequence was used, or the "weighting", look at CSF (and vitreous).
  - If CSF is dark --> T1-weighted image
  - If CSF is bright --> T2-weighted image
**Right parietal lobe tumor**

Proton Density  | T-1 Weighted | T-2 Weighted |
--- | --- | ---
View anatomy | View lesions |

**MRI: When to order contrast?**

- Consider ordering MRI both with and without contrast when:
  - suspect vascular disease or infarct
  - suspect inflammation/infiltration of orbital contents
  - suspect an intraorbital/intracranial mass

- **Gadolinium**
  - Non-iodine based contrast agent
  - Safer, less allergy than CT agents
  - Pathology shows areas of “enhancement” w/contrast
  - Use T-1 weighted images to compare

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**Functional MRI (fMRI)**

- Use of MRI to measure quick, tiny metabolic changes in an active part of the brain.
- This information can be useful for planning surgery, radiation therapy, treatment for stroke.
- Map brain activation in response to stimuli and place this on an anatomical image.
  - Example is visual cortex activity

**Functional MRI (fMRI)**

- **Retinotopic map**
  - Cortical activity from healthy retina
  - Cortical activity from diseased retina
**Ordering Protocols**

- Communicate with radiologist
  - Reason(s) for imaging
  - Clinical findings, Ddx.
  - Type of study (i.e. CT, MRI)
  - Region(s) to study, fat suppression (orbit MRI)
  - Contrast?
  - Width of cuts: thinner thru orbits
  - Patient health history (allergies, meds, metallic)

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**Scanning the Body: Directional Planes**

- Three directional planes exist in the brain:
  - medial/lateral = transverse (axial)
  - rostral/caudal = coronal
  - dorsal/ventral = sagittal

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**Directional Planes: MRI**

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**Image Interpretation: A clinical approach**

- Examine the patient.
- Determine possible cause(s) of problem.
- Select appropriate type of imaging study.
- Examine the image, noting type of scan, orientation, and limitations.
  - “This is a coronal MRI of the brain done with contrast.”
  - Note name and age on film to avoid mix-up!
**Image Interpretation**

- Identify and describe abnormal findings on scan.
- Review common causes of abnormal findings, then prioritize the differential diagnoses.
- Combine radiology findings with patient history and other clinical data to establish diagnosis.
- Are imaging results c/w clinical findings?
- Formulate an appropriate management plan in conjunction with PCP and sub-specialties.

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**ACR APPROPRIATENESS CRITERIA**

<table>
<thead>
<tr>
<th>Variant A</th>
<th>Young adult with sudden onset of paroxysmal visual loss.</th>
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<tbody>
<tr>
<td>Radiology Exam Procedure</td>
<td>Appropriateness Rating</td>
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<tr>
<td>MRI</td>
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<tr>
<td>MRI with contrast</td>
<td>0</td>
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<tr>
<td>CT</td>
<td>0</td>
</tr>
<tr>
<td>CT with contrast</td>
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<td>US</td>
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<tr>
<td>Ultrasound B</td>
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<td>IMR</td>
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<tr>
<td>IMR with contrast</td>
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<tr>
<td>CT</td>
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</tr>
<tr>
<td>CT with contrast</td>
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<tr>
<td>IMR</td>
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<tr>
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<table>
<thead>
<tr>
<th>Variant B</th>
<th>Adult patient with progressive proptosis and gradual visual loss.</th>
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**What to Order When**

<table>
<thead>
<tr>
<th>Structure(s)</th>
<th>Diagnosis</th>
<th>Type of Imaging</th>
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<tbody>
<tr>
<td>Bony orbit</td>
<td>Blunt oculofacial trauma</td>
<td>Plain Films (X-ray)</td>
</tr>
<tr>
<td>Orbital contents</td>
<td>Orbital cellulitis</td>
<td>Computed Tomography (CT)</td>
</tr>
<tr>
<td>Orbit and brain</td>
<td>Orbital tumors</td>
<td>MRI</td>
</tr>
<tr>
<td>Neuro-vascular</td>
<td>Aneurysm, AVM</td>
<td>MRA, Cerebral Ang</td>
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<td>Cardiovascular</td>
<td>HTN, Amaurosis fugax</td>
<td>Echocardiography, Carotid Doppl</td>
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<td>Histoplasmosis</td>
<td>Plain Films, CT</td>
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<td>Crohn’s ulcerative colitis</td>
<td>Barium X-ray, CT</td>
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<tr>
<td>Respiratory</td>
<td>Sarcoïdosis, TB</td>
<td>Chest X-ray, CT</td>
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<tr>
<td>Musculoskeletal</td>
<td>Thymoma (Myasthenia)</td>
<td>Plain Chest X-ray, CT</td>
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<tr>
<td>Ear, Nose, Throat</td>
<td>Thyroid disease</td>
<td>Thyroid scan, Iodine uptake</td>
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<tr>
<td>Breast</td>
<td>Primary tumor or mets</td>
<td>Mammography, CT, MRI</td>
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Summary of Key Points

- Today’s optometrists routinely care for patients that require neuroimaging studies.
- Radiology findings combined with patient history and other clinical data help establish a diagnosis and formulate an appropriate management plan.
- We should be familiar with radiologic testing in order to work with other providers on behalf of our patients.

Thanks for spending your precious time with me!

Joseph J. Pizzimenti, OD
pizzimen@nova.edu

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